

Regulatory structures used in protected cultivation of vegetable crops



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Classification of protected structures

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graph TD; A[Classification of protected structures] --> B[Utility]; A --> C[Shape of Structure]; A --> D[Construction]; A --> E[According to the Covering Material]; A --> F[Cost of investment]; A --> G[Type of Ventilation];
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Utility

Shape of Structure

Construction

*According to the
Covering Material*

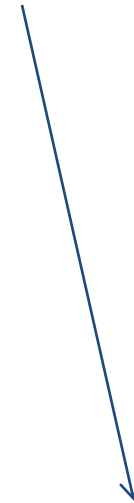
*Cost of
investment*

*Type of
Ventilation*

Based on utility



*Active heating system of
polyhouses*



*Active cooling system of
polyhouses*

Active heating system of greenhouses

- ❑ During the night time, air temperature inside greenhouse decreases.
- ❑ To avoid the cold bite to plants due to freezing, some amount of heat has to be supplied. The requirements for heating greenhouse depend on the rate at which the heat is lost to the outside environment.
- ❑ Various methods are adopted to reduce the heat losses, viz., using double layer polyethylene, thermo pane glasses (Two layers of factory sealed glass with dead air space) or to use heating systems, such as unit heaters, central heat, radiant heat and solar heating system.

Active cooling system of greenhouses

- ❑ During summer season, it is desirable to reduce the temperatures of greenhouse than the ambient temperatures, for effective crop growth.
- ❑ Hence suitable modifications are made in the greenhouse so that large volumes of cooled air is drawn into greenhouse, This type of greenhouse either consists of evaporative cooling pad with fan or fog cooling.
- ❑ This greenhouse is designed in such a way that it permits a roof opening of 40% and in some cases nearly 100%.

Based on shape of structure

Structural components of greenhouse

- ❖ The greenhouse is a structure made by assembling different parts or components. Each part has specific role in greenhouse structure. It is covered with a transparent material for admitting natural light for plant growth. The main components of greenhouse like structure, covering/glazing and temperature control systems need proper design for healthy growth of plants.
- ❖ Freestanding (single) or ridge and furrow (gutter connected) greenhouses are two common styles of commercial greenhouses.
- ❖ The freestanding style is often a Quonset, which will accommodate many growing situations but presents height restrictions near the side walls.
- ❖ Another freestanding style is the single gable greenhouse and its many variations. The ridge and furrow or gutter connected greenhouses are joined at the eave by a common gutter. When several of these buildings are joined they are often referred to as a greenhouse range.

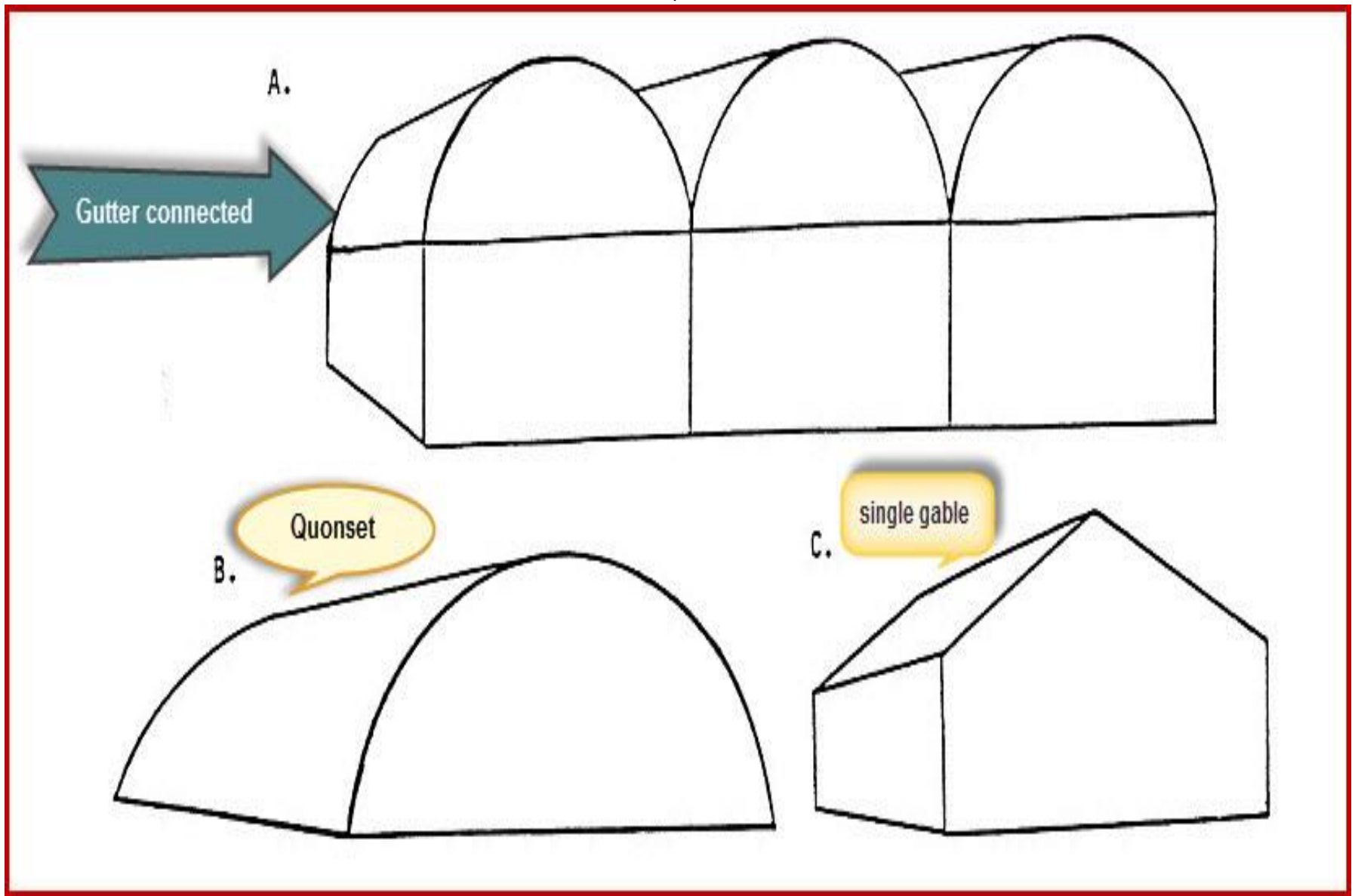


Fig- Commercial greenhouse structures: A) gutter connected, B) Quonset, and C) single gable.

Components

1. Side wall:

- It supports the trusses and bears the weight of the greenhouse.
- Set in concrete footings.
- Typically spaced 10 feet apart.

2. Curtain wall:

- The first several feet of sidewall above the soil line.
- Usually made of some solid building material such as poured concrete, concrete blocks, bricks or treated lumber.

3. Sill:

- It is top of the curtain wall.

Components

4. Eave:

- Where the sides of the greenhouse join the roof of the greenhouse.
- The “top” of the sides of the greenhouse.

5. Truss:

- Structural component that supports the weight of the greenhouse roof.
- Consists of rafters, struts and chords.

6. Purlin:

- Purlins run along the length of the greenhouse.
- Keeps the roof trusses aligned.

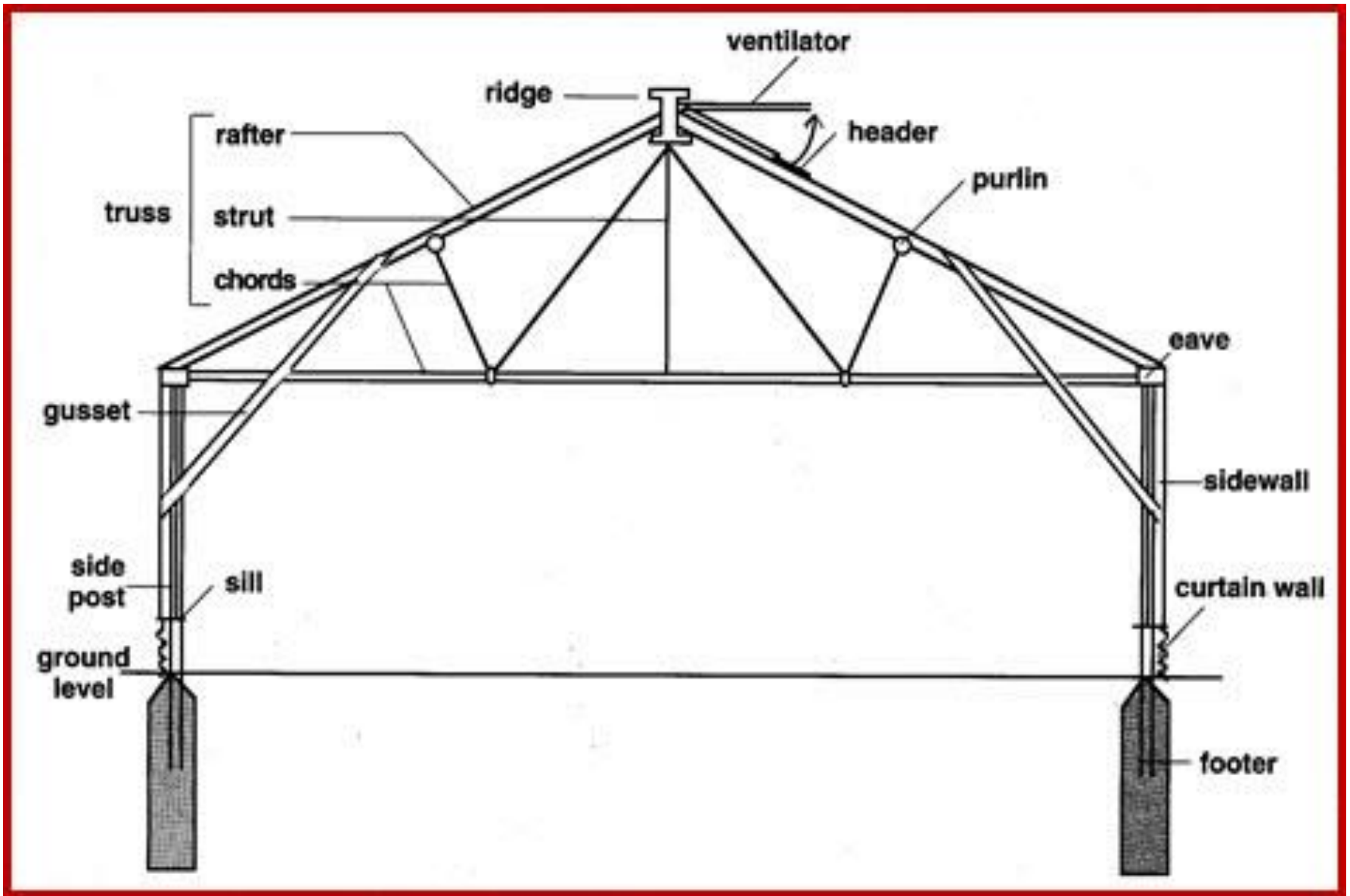
Components

7. Ridge:

- Where the roofs come together at the top of the greenhouse.
- Many greenhouses have a ridge vent(s).

8. Side posts and columns:

- These are vertical supports that dictate the height of the production area.
- These range from one to ten feet in height and should be given serious consideration since they directly influence efficiency.



Basic structural components of greenhouse

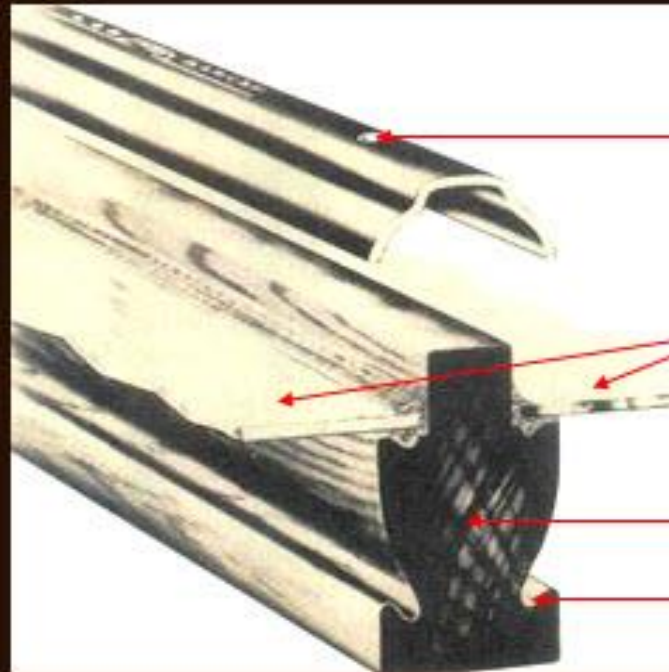
Component

9. Sash bar:

- Run perpendicular to the purlins.
- Attached to the purlins.
- Hold the glazing in place.
- Sometimes built with a drip groove or channel to catch condensation that forms on the inside of the glass panels.

Purlin

Sash bars



Sash bar cap

Glass panels

Sash bar

Drip groove

Aluminum sash Bar



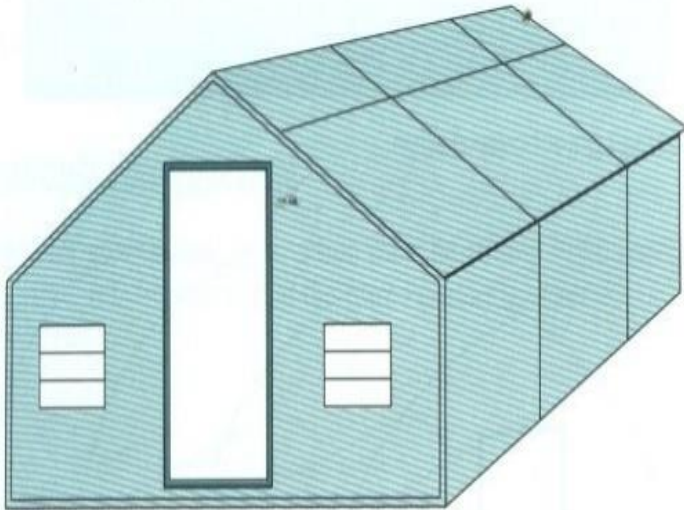
1. Lean-to type greenhouse

- ✓ A lean-to types of greenhouse is applicable when it is placed against the side of an existing greenhouse structure for one or more of its sides. The roof of the existing greenhouse structure is extended with covering material and the exposed area is properly covered.
- ✓ The whole structure should faced south side which is the best direction for adequate sun exposure.
- ✓ This type of greenhouse is limited to single or double-row plant benches with a total width of 7 to 12 feet and length can be as the building it is attached to the structure.
- ✓ The advantages of the lean-to type greenhouse are, usually it is a least expensive structure.
- ✓ This types of greenhouse makes the best use of sunlight and minimizes the requirement of roof supports.
- ✓ Whereas limited space, limited light, limited ventilation and temperature control are the following disadvantages.

2. Even span type greenhouse

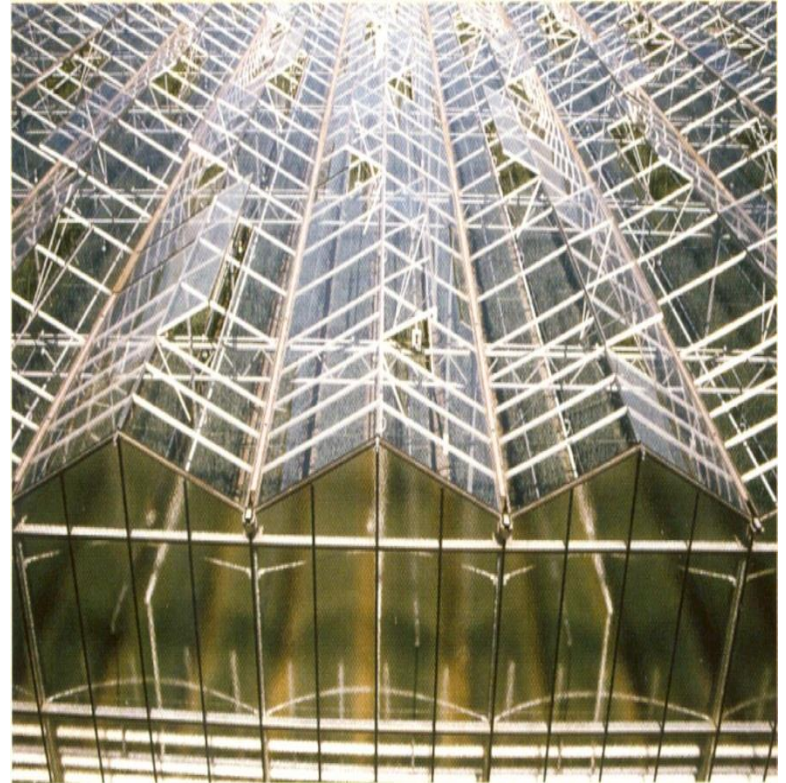
- The even span is the common type of greenhouse constructed fully on ground level with the two equal width and pitch of roof slopes. This type of greenhouse structure is used when the size of greenhouse is small and attached to a house at one gable end.
- This type of greenhouse is restricted to 2 or 3 rows of plant benches.
- The price of an even-span greenhouse structure is more as compared to the cost of a lean-to type, but it has eminent plasticity in design and suitable for more plants.
- Because the size of greenhouse structure and substantial amount of uncover glass area, it will cost more to heat.
- The design has better shape as compared to a lean-to type for air movement inside the structure to maintain uniform temperatures during the winter season. It accommodates two side benches, two walks and a wide centre bench.
- There are different types of single and multiple span structures available in various regions of India. For single span type the span in general, varies from 5 to 9 m, whereas the length is around 24 m and the height varies from 2.5 to 4.3 m.

Even-span Type



A freestanding even-span American design greenhouse.

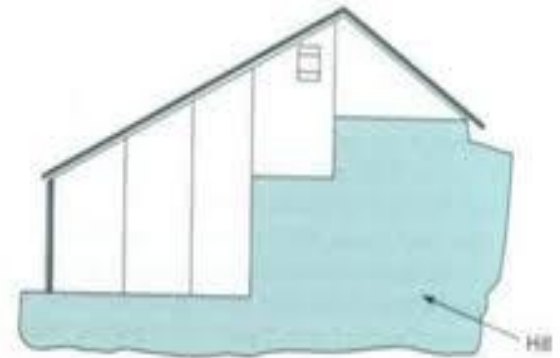
Single span



Multi span type

3. Uneven span type greenhouse

- ❖ This uneven span type of greenhouse is suitable for hilly or undulating terrains.
- ❖ The roofs of the structure differ in width; which resembles the name of the structure and make the structures adaptable to the side slopes of hill.
- ❖ These having different pitch angles.
- ❖ This type of greenhouses are rarely used as it is not adaptable for automation.
- ❖ Wider roof faces south for maximum solar gain.



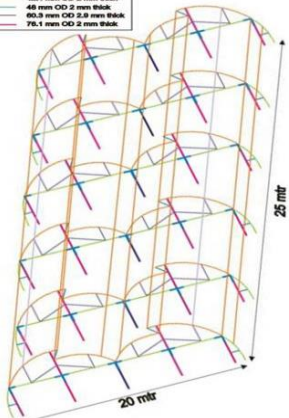
4. Ridge and furrow type greenhouse

- ❑ This type of greenhouse designs use two or more A-frame greenhouse structure connected to one another along the length of the eave.
- ❑ The eave represent as gutter or furrow to handle rain water and melted snow. The side wall is eradicated between the greenhouses, seems structure with a single large interior.
- ❑ The interior space in greenhouse structure reduces labour, minimize the price of automation, upgrade personal management and less consumption of fuel as there is less uncovered wall area through which heat escapes.
- ❑ The snow stuffs must be taken into the frame specifications of these greenhouses since the snow cannot slide off the roofs as in case of individual free standing greenhouses, but melts away. In spite of snow loads, ridge and furrow greenhouses are effectively used in northern countries of Europe and in Canada and are well.

5. Saw tooth type greenhouse










- ❖ This type of greenhouses are similar to ridge and furrow types, except that this type provides natural ventilation.
- ❖ While opening, the saw tooth vent allows a continuous airflow to reduce the inside temperature or can be closed to optimise the climate control of the growing area.
- ❖ The roof ventilation alone provides 25% of the total ventilation of the covered area, in addition to the side ventilation. The shape of the arches allows excellent light transmission.

33 mm OD 2 mm Black
42.4 mm OD 2 mm Black
48 mm OD 2 mm Black
60.9 mm OD 2.5 mm Black
76.1 mm OD 2 mm Black



6. Quonset greenhouse

- Pipe arches are used to provide support by pipe purling running along the distance of the quonset type greenhouse.
- In general, polyethylene is used as covering material.
- This greenhouse is useful for a small isolated cultural area and also economical as compared to the gutter connected greenhouses.
- These houses are connected either in free, standing style or arranged in an interlocking ridge and furrow. In the interlocking type, truss members overlap sufficiently to allow a bed of plants to grow between the overlapping portions of adjacent houses.

1		Multi span trellis girder (Venlo type)	Having long life but expensive
2		Saw tooth Multi span	Old model for tropic & subtropics
3		Wide span	Low cost , No top ventilation
4		Pitched saw tooth with Permanent ventilation	For tropic & subtropics
5		Arched saw tooth with permanent ventilation	For tropic & subtropics, medium cost
6		Arched wide span	Low cost
7		Tunnel type	Low cost for small holding at temperate
8		Maxi vent type	Tropical areas
9		Flat type	Low cost used mostly for seedling



Wide Span Type



Chained Tunnel Type

Flat Type



Poly tunnel



Based on construction

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graph TD; A[Based on construction] --> B[Wooden framed structures]; A --> C[Pipe framed structures]; A --> D[Truss framed structures];
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Wooden framed structures

Pipe framed structures

Truss framed structures

- ❑ The construction of greenhouse is predominantly powered by the structural material though the covering material also influences the types of greenhouse.**
- ❑ Span of the green house determines the selection of structural components and their construction.**
- ❑ Huge the span, more efficient should be the material and more structural components are used to make sturdy truss type frames.**
- ❑ For smaller spans, simpler designs like hoops can be followed. Greenhouses are broadly classified as wooden framed, pipe framed and truss framed structures based on construction.**

1. Wooden framed structures

In general, wooden frame structures are applicable where greenhouses with span is less than 6 m. Side posts and columns are made up of wooden materials without the use of a truss materials. Pine wood is commonly used as it is inexpensive and possesses good strength. Similarly, locally available timber can be used for the construction of greenhouse as they are good in strength, durability and machinability.



2. Pipe framed structures

- Pipes are used for construction of greenhouses, when the clear span is around 12m.
- In general, the side posts, columns, cross ties and purlins are constructed using pipes.
- In this type, the trusses are not used.

3. Truss framed structures

Green house structures can be made in truss frames, if the span is greater than or equal to 15m. Flat steel, tubular steel or angular iron is welded together to form a truss encompassing rafters, chords and struts. Struts are support members under compression and chords are support members under tension. Angle iron purlins running along the length of greenhouse are bolted to each truss. Columns are used only in very wide truss frame houses of 21.3 m or more. Most of the glass houses are made in truss frame, as these frames are highly suitable for pre-fabrication.

According to the covering material –

- Flexible covering material e.g. polythene, shade net etc.
- Rigid covering material e.g. glass, poly carbonate sheets etc



Poly house and shade house

- ❖ **The principal component of the greenhouse structure is covering materials.**
- ❖ **They are directly influenced by greenhouse effect of interior part of the structure and manipulate the air temperature inside the greenhouse.**
- ❖ **Selection of frame types and method of fixing also varies with the covering materials.**
- ❖ **Greenhouses are classified as glass, plastic film and rigid panel greenhouses based on the type of covering materials.**

Glass greenhouses

- Glass is used as covering material in glass greenhouses.
- As a covering material, it has the advantage of greater interior light intensity, have higher air infiltration rate and leads to lower interior humidity and excellent disease prevention quality.
- Ridge and furrow, lean-to type, even span type of designs are used for construction of glass greenhouse.



Plastic film greenhouses

- ❖ The covering materials of flexible plastic films including polyvinyl chloride, polyethylene and polyester which are used in this type of greenhouses. As a covering material for greenhouses, plastics are more popular and cheap as compared to glass greenhouses.
- ❖ Plastic films have short lifespan which is the main disadvantage of this covering material. For example, the best quality ultraviolet (UV) stabilized film can last for four years only. Quonset design as well as gutter-connected design is suitable for using this covering material.

Rigid panel greenhouses

Quonset type frame is also known ridge and furrow type frame material in which polyvinyl chloride rigid panels, fibre glass-reinforced plastic, acrylic and polycarbonate rigid panels are used as the covering material in greenhouse. These materials provide more uniform light intensity throughout the greenhouse and also resistant to breakage than plastic or glass. High grade panels are more durable even up to 20 years. But the panels move to collect dust and also harbour algae, are the main disadvantage of rigid panel types greenhouse, results in dimness of the panels and gradually incline the light transmission.

Based on cost investment

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graph TD; A[Based on cost investment] --> B[Low cost polyhouses]; A --> C[High cost polyhouses]; A --> D[Medium cost polyhouses];
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Low cost polyhouses

High cost polyhouses

Medium cost polyhouses

Low cost polyhouses

- ✓ The size of the low technology greenhouses is less than 3 metres in total height. The most common type low technology greenhouses involve tunnel houses provide poor ventilation as they do not have vertical walls.
- ✓ This type of structure is relatively inexpensive due to little or no automation is used. However, this type of structure provides basic advantages for crop production as compared to open field production.
- ✓ Crop potential is still limited by the growing environment and crop management is somewhat difficult. Low technology greenhouses generally provide suboptimal growing environment and little reduction in the incidence of pests and diseases.
- ✓ However, low technology greenhouses offer a cost effective entry to the farming industry.



Other Low Cost Greenhouse Structures



Low Cost poly house



Low cost Shade net house



Low Cost Poly tunnel



Medium cost polyhouses

Medium technology greenhouses are typically characterised by vertical walls. The size of the medium technology greenhouses is more than 2m but less than 4 metres tall and a total height usually less than 5.5 metres. These types of green houses facilitate either roof or side wall for better ventilation. They also provide medium automation and usually use clad with either single or double skin plastic film or glass. Medium level greenhouses offer a compromise between cost and productivity and represent a reasonable economic and environmental basis for the farming industry. Crop production in medium level greenhouses is more efficient than open field production. Hydroponic systems increase the efficiency of water use. There is greater opportunity to use non-chemical pest and disease management strategies but overall the full potential of greenhouse is difficult to attain.

High cost polyhouses

Height of high level greenhouses wall is at least 4 metres and height of roof peak is up to 8 metres above ground level. These structures offer excellent crop production with environmental performance. This structure has proper roof ventilation and also side wall vents. Cladding materials used in high level greenhouse are plastic film (single or double), polycarbonate sheeting or glass. There is automation environmental controls. These structures offer enormous opportunities for economic and environmental sustainability. Use of pesticides also significantly reduced. High technology structures provide a generally impressive sight and internationally, are increasingly being involved in agribusiness opportunities. Although these greenhouses are capital intensive, they offer a highly productive, environmentally sustainable opportunity for an advanced fresh produce industry. Investment decisions should, wherever possible, look to install high technology greenhouses.



According to the type of ventilation-

- Naturally Ventilated



Maxi vent type



Gutter ventilation



Saw Tooth Ventilation

- Mechanically (Induced) Ventilated- (Fan and pad ventilated type)



Greenhouse for the tropics and subtropics

The greenhouse construction has to withstand heavy rainfall, high wind speed and high temperature weather conditions in subtropical and tropical regions.. The strength of the covering material is also important for tropical and subtropical regions. It has to withstand local wind speeds and ageing effect by UV radiation, chemicals used in the greenhouses, thermal and mechanical stress and air pollution.



Greenhouse for the Temperate

The greenhouse construction has to withstand foggy climate, snowfall and low temperature conditions in temperate region. Use of heating system is beneficial for this type of polyhouse to prevent the crop from chilling injuries.



Selection of site

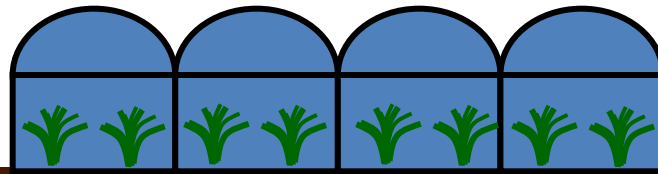
- Leveled
- Well drained soil
- Roads
- Water
- Electricity
- Labour availability
- Shadow free
- Communication
- Future expansion

Orientation of greenhouses

NORTH

WEST

EAST



SOUTH

Orientation of greenhouses

NW

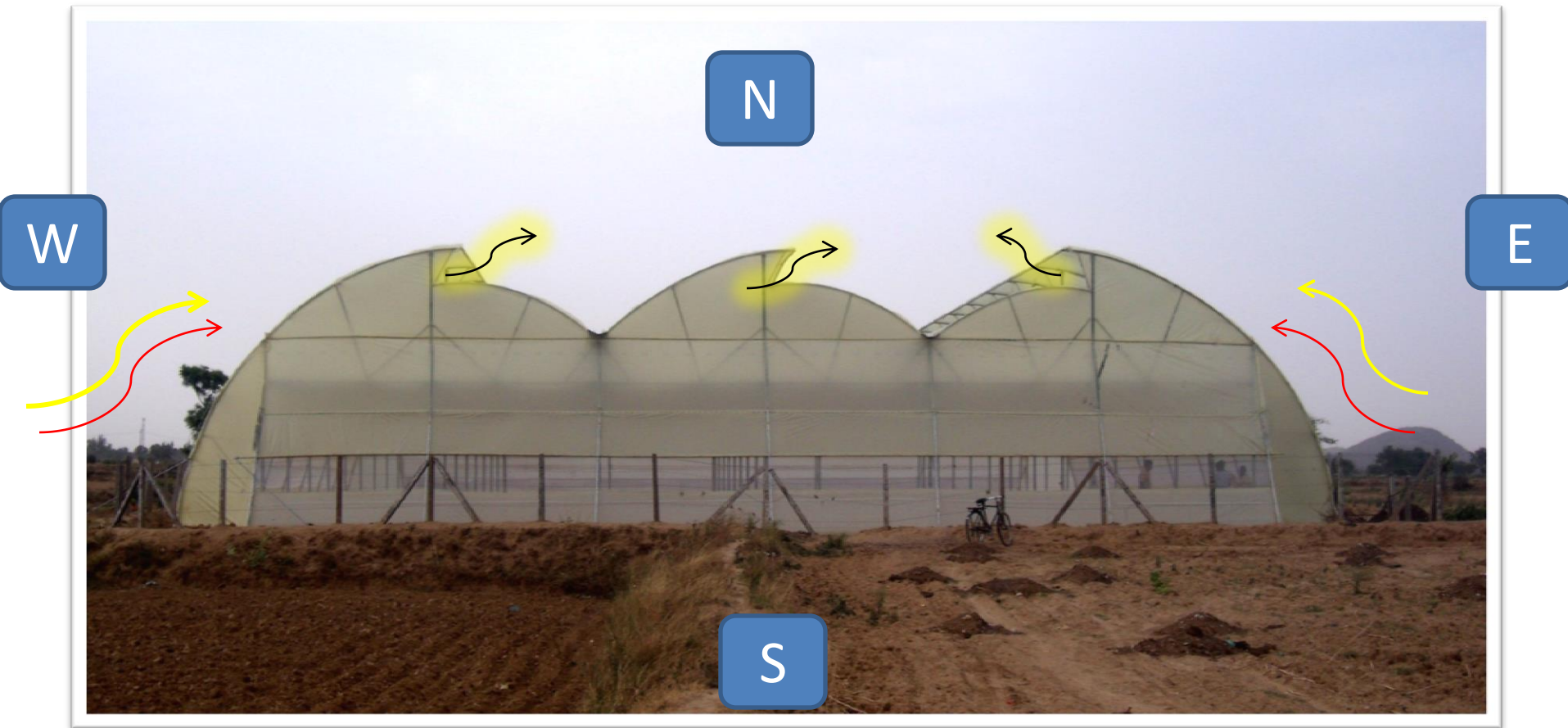


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Orientation continued...



Major factors- Light intensity, Wind direction and Velocity

- Gutter should be placed in north-south direction
- Vent opening towards East side.
- Lengthwise slope 0 to 2%
- widthwise slope not more than 1.25%

Structure Erection

All the main columns, side columns, arches, purlins and gutters are fitted as per the design and layout.

Claddings

There are different types of cladding (covering) materials used for constructing greenhouses such as Glass, Polythene, Polycarbonates sheets, Shade Nets etc.

POLY FILMS- In plastic green houses poly film is mainly used as cladding material. C – Shaped profiles with zigzag spring are used to fix polythene.

PROPERTIES OF POLYFILM

- Light transmission- 88 %
- Strength
- Thermicity
- Diffused film
- Thickness- 200 microns
- Life time - 2-3 years
- Ultra Violet- UV absorbers and stabilizers
- Anti dust- avoids dust particles on film
- Anti fogging- avoids water drops
- Anti petal blackening- UV block film
- Anti algae- avoids algae in heavy rainfall area



SHADE NETS

Shade nets are used as cladding in shade houses and movable shading screen system in poly houses. In warm countries such as Israel, India shading systems are used to reduce the heat build up inside the green house during the hot hours of the day.



90%



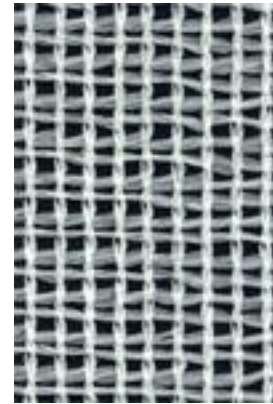
80%



60%



60%



40%

Gripper (Zig-Zag Spring)





Thank You !!!

